



# **Technical Report Series on the Biosystem-Aerosphere Study (BOREAS)**

*William J. Shuttleworth and Karl Huemmrich, Editors*

**194**

## **NASA TF-2 SSA-OA Tethersonde Ozone Data**

*by J. W. M. Young and R.E. Mickle*

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## **Technical Report Series on the Boreal Ecosystem-Atmosphere Study (BOREAS)**

*Forrest G. Hall and Karl Huemmrich, Editors*

### **Volume 194**

## **BOREAS TF-2 SSA-OA Tethersonde Meteorological and Ozone Data**

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Springfield, VA 22161  
Price Code: A10

# **BOREAS TF-2 SSA-OA Tethersonde Meteorological and Ozone Data**

A. James Arnold, Robert E. Mickle

## **Summary**

The BOREAS TF-2 team collected meteorological and ozone measurements from instruments mounted below a tethered balloon. These data were collected at the SSA-OA site to extend meteorological and ozone measurements made from the flux tower to heights of 300 m. The tethersonde operated during the fall of 1993 and the spring, summer, and fall of 1994. The data are available in tabular ASCII files.

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## **1. Data Set Overview**

### **1.1 Data Set Identification**

BOREAS TF-02 SSA-OA Tethersonde Meteorological and Ozone Data

### **1.2 Data Set Introduction**

A tethersonde program was carried out at the BOREal Ecosystem-Atmosphere Study (BOREAS) Southern Study Area (SSA) Old Aspen (OA) site to extend meteorological and ozone measurements made from the flux tower to heights of 300 m. Launched from a clearing approximately 100 m from the main tower, an Atmospheric Instrumentation Research (AIR) tethersonde package was mounted below a 25-m<sup>3</sup> tethered balloon and profiled during selected periods of the field experiment. For most of the profiles, a Mast-Brewer ozone sonde was coupled to the tethersonde. Data were collected in the fall of 1993 and during the Intensive Field Campaigns (IFCs) of 1994.

### **1.3 Objective/Purpose**

The purpose of this study was to characterize the atmosphere's vertical structure in terms of air pressure, temperature, humidity, winds, and ozone concentration to complement and extend the data being collected from the SSA-OA flux tower and flux aircraft.

## **1.4 Summary of Parameters and Variables**

From the tethersonde, vertical profiles of air temperature, potential temperature, relative humidity, air pressure, wind speed and direction, and ozone concentration were collected. Measurements were located along the profiles by the height above ground level.

## **1.5 Discussion**

This study measured high-resolution vertical profiles of temperature, humidity, pressure, wind speed and direction, and ozone concentration in the lower atmospheric boundary layer. An AIR tethersonde package (TS-3A-SP) was mounted below a 25 m<sup>3</sup> tethered balloon and profiled during selected periods of the field experiment. For most of the profiles, a Mast-Brewer ozone sonde (AIR OZ-3A-T) was coupled to the tethersonde. The tethersonde was raised and lowered using a heavy-duty winch.

## **1.6 Related Data Sets**

BOREAS TF-02 SSA-OA Tower Flux and Meteorological Data

BOREAS TF-01 SSA-OA Undercanopy Flux, Meteorological, and Snow/Soil Temp Data

# **2. Investigator(s)**

## **2.1 Investigator(s) Name and Title**

Robert E. Mickle  
Atmospheric Environment Service

A. James Arnold  
Atmospheric Environment Service

## **2.2 Title of Investigation**

AES Flux Tower Measurements for BOREAS: Exchange of Energy, Water Vapor, and Trace Gases Project

## **2.3 Contact Information**

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Greenbelt, MD 20771  
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(301) 286-0239 (fax)  
Karl.Huemmrich@gsfc.nasa.gov

### **3. Theory of Measurements**

A helium-filled balloon can lift instruments off of the ground and provides a stable platform for measurements at altitudes higher than can be reached by towers. Tethering the balloon allows control of the balloon's altitude and ensures retrieval of the attached instruments. The tether also lets one control the rates of ascent and descent. Because of these features, the tether sonde is able to provide high-resolution vertical profiles of the characteristics of the lower atmospheric boundary layer.

### **4. Equipment**

#### **4.1 Sensor/Instrument Description**

##### **4.1.1 Collection Environment**

The tether sonde could not be launched under conditions of high wind speeds.

##### **4.1.2 Source/Platform**

Instruments were attached below a 25-m<sup>3</sup> tethered balloon. The tether sonde was launched from a clearing approximately 100 m from the SSA-OA flux tower. The tether sonde reached heights of 300 m, and was raised and lowered using a heavy-duty winch.

##### **4.1.3 Source/Platform Mission Objectives**

The purpose of the tether sonde was to allow vertical profiles of atmospheric variables to be measured at heights greater than the flux tower.

##### **4.1.4 Key Variables**

Vertical profiles of air temperature, potential temperature, relative humidity, air pressure, wind speed and direction, and ozone concentration were collected. Measurements were located along the profiles by the height above ground level.

##### **4.1.5 Principles of Operation**

The tether sonde supported an AIR tether sonde package (TS-3A-SP). The sensors include dry and wet bulb thermistors, an aneroid capacitance barometer, a three-cup anemometer with tachometer, and a magnetic compass. Humidity was obtained using dry and wet bulb measurements and the psychrometric equation. For most of the profiles a Mast-Brewer ozone sonde (AIR OZ-3A-T) was coupled to the tether sonde.

##### **4.1.6 Sensor/Instrument Measurement Geometry**

The instruments were suspended under a 25-m<sup>3</sup> balloon. The height of the measurements and the rate of ascent or descent were controlled by the winch on the ground.

#### **4.1.7 Manufacturer of Sensor/Instrument**

Tethersonde package (TS-3A-SP) and ozone sonde (AIR OZ-3A-T):

AIR, Inc.  
8401 Baseline Rd.  
Boulder, CO 80303  
(303) 499-1701  
(303) 499-1767 (fax)  
rons@airmfg.com

## **4.2 Calibration**

### **4.2.1 Specifications**

Factory calibrations for the meteorology package provided sensor precision of 0.5 °C for air temperature, 5 percent for relative humidity, 1 mb for the aneroid barometer, 0.25 m/s for wind speed, and 5° for wind direction. Prior to and after each profile, the ozone sonde was calibrated against a Dasibi (Model 1008-RS) calibrator/analyzer to minimize drift due to cell aging. Calibrations were repeatable to within 3 ppb.

#### **4.2.1.1 Tolerance**

The wet and dry bulb thermistors operated over a range of 50 to -70 °C with a precision of 0.5 °C and a resolution of 0.01 °C. The aneroid barometer operated over a range of 1050 to 600 mb with a precision of 1 mb and a resolution of 0.1 mb. The anemometer measured wind speed over the range 0 to 20 m/s with a precision of 0.25 m/s and a resolution of 0.01 m/s. The wind direction was measured over a range of 2 to 358° with a precision of 5° and a resolution of 1°.

### **4.2.2 Frequency of Calibration**

Prior to and after each profile, the ozone sonde was calibrated against a Dasibi (Model 1008-RS ) calibrator/analyzer to minimize drift due to cell aging.

### **4.2.3 Other Calibration Information**

None.

## **5. Data Acquisition Methods**

Launched from a clearing approximately 100 m from the main tower, an AIR tethersonde package was mounted below a 25 m<sup>3</sup> tethered balloon and profiled during selected periods of the field experiment. The height of the measurements and the rate of ascent or descent were controlled by the winch on the ground. The tethersonde could not be launched under conditions of high wind speeds.

## **6. Observations**

### **6.1 Data Notes**

None.

### **6.2 Field Notes**

None.



## 7. Data Description

### 7.1 Spatial Characteristics

#### 7.1.1 Spatial Coverage

All data were collected at the BOREAS SSA-OA site. The tether sonde was launched from a clearing 100 m from the flux tower. The North American Datum of 1983 (NAD83) coordinates for the SSA-OA flux tower are latitude 53.62889° N, longitude 106.19779° W, and elevation of 600.63 m.

#### 7.1.2 Spatial Coverage Map

Not available.

#### 7.1.3 Spatial Resolution

The spatial resolution of the measurements is dependent on sonde height and atmospheric conditions.

#### 7.1.4 Projection

Not applicable.

#### 7.1.5 Grid Description

Not applicable.

### 7.2 Temporal Characteristics

#### 7.2.1 Temporal Coverage

Data were collected in 1993 from 17-Oct to 31-Oct. In 1994, data were collected during the periods of 26-May to 12-Jun, 21-Jul to 09-Aug, and 31-Aug to 19-Sep, corresponding to the IFCs.

#### 7.2.2 Temporal Coverage Map

None.

#### 7.2.3 Temporal Resolution

Samples were collected at a rate of one every 10 seconds.

### 7.3 Data Characteristics

#### 7.3.1 Parameter/Variable

The parameters contained in the data files on the CD-ROM are:

```
Column Name
-----
SITE_NAME
SUB_SITE
DATE_OBS
TIME_OBS
HT_AGL
ATMOSPHERIC_PRESS
AIR_TEMP
REL_HUM
POTENTIAL_TEMP
WIND_SPEED
WIND_DIR
OZONE_CONC
CRTFCN_CODE
REVISION_DATE
```

### 7.3.2 Variable Description/Definition

The descriptions of the parameters contained in the data files on the CD-ROM are:

Column Name	Description
SITE_NAME	The identifier assigned to the site by BOREAS, in the format SSS-TTT-CCCC, where SSS identifies the portion of the study area: NSA, SSA, REG, TRN, and TTT identifies the cover type for the site, 999 if unknown, and CCCC is the identifier for site, exactly what it means will vary with site type.
SUB_SITE	The identifier assigned to the sub-site by BOREAS, in the format GGGGG-IIIII, where GGGGG is the group associated with the sub-site instrument, e.g. HYD06 or STAFF, and IIIII is the identifier for sub-site, often this will refer to an instrument.
DATE_OBS	The date on which the data were collected.
TIME_OBS	The Greenwich Mean Time (GMT) when the data were collected.
HT_AGL	The height above ground at which the measurements were taken.
ATMOSPHERIC_PRESS	The atmospheric pressure.
AIR_TEMP	The air temperature.
REL_HUM	The calculated relative humidity.
POTENTIAL_TEMP	The measured potential temperature.
WIND_SPEED	The wind speed.
WIND_DIR	The direction from which the wind was traveling, increasing in a clockwise direction from north.
OZONE_CONC	The ozone concentration.
CRTFCN_CODE	The BOREAS certification level of the data. Examples are CPI (Checked by PI), CGR (Certified by Group), PRE (Preliminary), and CPI-??? (CPI but questionable).
REVISION_DATE	The most recent date when the information in the referenced data base table record was revised.

### 7.3.3 Unit of Measurement

The measurement units for the parameters contained in the data files on the CD-ROM are:

Column Name	Units
SITE_NAME	[none]
SUB_SITE	[none]
DATE_OBS	[DD-MON-YY]
TIME_OBS	[HHMM GMT]
HT_AGL	[meters]
ATMOSPHERIC_PRESS	[kiloPascals]
AIR_TEMP	[degrees Celsius]
REL_HUM	[percent]
POTENTIAL_TEMP	[degrees Kelvin]
WIND_SPEED	[meters][second <sup>-1</sup> ]
WIND_DIR	[degrees]

OZONE_CONC	[parts per billion]
CRTFCN_CODE	[none]
REVISION_DATE	[DD-MON-YY]

### 7.3.4 Data Source

The sources of the parameter values contained in the data files on the CD-ROM are:

Column Name	Data Source
SITE_NAME	[Assigned by BORIS.]
SUB_SITE	[Assigned by BORIS.]
DATE_OBS	[Supplied by Investigator.]
TIME_OBS	[Supplied by Investigator.]
HT_AGL	[measurement of cable]
ATMOSPHERIC_PRESS	[aneroid capacitance barometer]
AIR_TEMP	[dry bulb thermistor]
REL_HUM	[dry and wet bulb thermistors]
POTENTIAL_TEMP	[dry and wet bulb thermistors]
WIND_SPEED	[cup anemometer]
WIND_DIR	[windvane]
OZONE_CONC	[Mast-Brewer ozone sonde]
CRTFCN_CODE	[Assigned by BORIS.]
REVISION_DATE	[Assigned by BORIS.]

### 7.3.5 Data Range

The following table gives information about the parameter values found in the data files on the CD-ROM.

Column Name	Minimum Data Value	Maximum Data Value	Missng Data Value	Unrel Data Value	Below Detect Limit	Data Not Cllctd
SITE_NAME	SSA-90A-FLXTR	SSA-90A-FLXTR	None	None	None	None
SUB_SITE	9TF02-TET01	9TF02-TET01	None	None	None	None
DATE_OBS	17-OCT-93	09-AUG-94	None	None	None	None
TIME_OBS	0	2359	None	None	None	None
HT_AGL	-839.6	324.17	-999	None	None	None
ATMOSPHERIC_PRESS	90.06	8888.888	-999	None	None	None
AIR_TEMP	-13.01	29.58	-999	None	None	None
REL_HUM	32.13	100	-999	None	None	None
POTENTIAL_TEMP	266.33	307.73	-999	None	None	None
WIND_SPEED	0	35.5	-999	None	None	None
WIND_DIR	.01	360	-999	None	None	None
OZONE_CONC	6.29	86.02	-999	None	None	None
CRTFCN_CODE	CPI	CPI	None	None	None	None
REVISION_DATE	04-AUG-99	04-AUG-99	None	None	None	None

Minimum Data Value -- The minimum value found in the column.

Maximum Data Value -- The maximum value found in the column.

Missng Data Value -- The value that indicates missing data. This is used to indicate that an attempt was made to determine the parameter value, but the attempt was unsuccessful.

Unrel Data Value -- The value that indicates unreliable data. This is used to indicate an attempt was made to determine the parameter value, but the value was deemed to be

unreliable by the analysis personnel.

Below Detect Limit -- The value that indicates parameter values below the instruments detection limits. This is used to indicate that an attempt was made to determine the parameter value, but the analysis personnel determined that the parameter value was below the detection limit of the instrumentation.

Data Not Cllected -- This value indicates that no attempt was made to determine the parameter value. This usually indicates that BORIS combined several similar but not identical data sets into the same data base table but this particular science team did not measure that parameter.

Blank -- Indicates that blank spaces are used to denote that type of value.

N/A -- Indicates that the value is not applicable to the respective column.

None -- Indicates that no values of that sort were found in the column.

---

## 7.4 Sample Data Record

The following are wrapped versions of data records from a sample data file on the CD-ROM.

```
SITE_NAME, SUB_SITE, DATE_OBS, TIME_OBS, HT_AGL, ATMOSPHERIC_PRESS, AIR_TEMP, REL_HUM,
POTENTIAL_TEMP, WIND_SPEED, WIND_DIR, OZONE_CONC, CRTFCN_CODE, REVISION_DATE
'SSA-90A-FLXTR', '9TF02-TET01', 01-JUN-94, 654, 0.0, 95.26, 9.13, -999.0, 286.23, .15,
177.0, 40.53, 'CPI', 04-AUG-99
'SSA-90A-FLXTR', '9TF02-TET01', 01-JUN-94, 654, -.29, 95.26, 9.13, -999.0, 286.23, .1,
177.0, 40.5, 'CPI', 04-AUG-99
'SSA-90A-FLXTR', '9TF02-TET01', 01-JUN-94, 655, -.58, 95.27, 9.16, -999.0, 286.25, .03,
183.0, 40.49, 'CPI', 04-AUG-99
```

## 8. Data Organization

### 8.1 Data Granularity

The smallest unit of data tracked by the BOREAS Information System (BORIS) was data collected at a given site on a given date.

### 8.2 Data Format

The Compact Disk-Read-Only Memory (CD-ROM) files contain American Standard Code for Information Interchange (ASCII) numerical and character fields of varying length separated by commas. The character fields are enclosed with single apostrophe marks. There are no spaces between the fields.

Each data file on the CD-ROM has four header lines of Hyper-Text Markup Language (HTML) code at the top. When viewed with a Web browser, this code displays header information (data set title, location, date, acknowledgments, etc.) and a series of HTML links to associated data files and related data sets. Line 5 of each data file is a list of the column names, and line 6 and following lines contain the actual data.

## **9. Data Manipulations**

### **9.1 Formulae**

#### **9.1.1 Derivation Techniques and Algorithms**

Humidity was obtained using dry and wet bulb measurements and the psychometric equation.

### **9.2 Data Processing Sequence**

#### **9.2.1 Processing Steps**

BORIS staff processed these data by:

- Reviewing the initial data files and loading them online for BOREAS team access.
- Designing relational data base tables to inventory and store the data.
- Loading the data into the relational data base tables.
- Working with the team to document the data set.
- Extracting the data into logical files.

#### **9.2.2 Processing Changes**

None.

### **9.3 Calculations**

#### **9.3.1 Special Corrections/Adjustments**

None given.

#### **9.3.2 Calculated Variables**

Humidity was obtained using dry and wet bulb measurements and the psychometric equation.

### **9.4 Graphs and Plots**

None given.

## **10. Errors**

### **10.1 Sources of Error**

Prior to and after each profile, the ozone sonde was calibrated against a Dasibi (Model 1008-RS ) calibrator/analyzer to minimize drift due to cell aging.

### **10.2 Quality Assessment**

#### **10.2.1 Data Validation by Source**

Data were examined by investigators to check for unreasonable values.

#### **10.2.2 Confidence Level/Accuracy Judgment**

None given.

#### **10.2.3 Measurement Error for Parameters**

The wet and dry bulb thermistors operated over a range of 50 to -70 °C with a precision of 0.5 °C and a resolution of 0.01 °C. The aneroid barometer operated over a range of 1050 to 600 mb with a precision of 1 mb and a resolution of 0.1 mb. The anemometer measured wind speed over the range 0 to 20 m/s with a precision of 0.25 m/s and a resolution of 0.01 m/s. The wind direction was measured over a range of 2 to 358° with a precision of 5° and a resolution of 1°.

#### **10.2.4 Additional Quality Assessments**

None.

#### **10.2.5 Data Verification by Data Center**

Data were examined to check for spikes, values that are four standard deviations from the mean, long periods of constant values, and missing data.

### **11. Notes**

#### **11.1 Limitations of the Data**

The tethersonde could not be launched under conditions of high wind speeds.

#### **11.2 Known Problems with the Data**

None given.

#### **11.3 Usage Guidance**

None given.

#### **11.4 Other Relevant Information**

None given.

### **12. Application of the Data Set**

The data can be used for monitoring the development of the boundary layer and atmospheric movement and condition. In addition, the data can be used for comparisons with field studies occurring during respective IFCs.

### **13. Future Modifications and Plans**

None.

### **14. Software**

#### **14.1 Software Description**

None.

#### **14.2 Software Access**

None.

### **15. Data Access**

The SSA-OA tethersonde meteorological and ozone data are available from the Earth Observing System Data and Information System (EOSDIS) Oak Ridge National Laboratory (ORNL) Distributed Active Archive Center (DAAC).

### **15.1 Contact Information**

For BOREAS data and documentation please contact:

ORNL DAAC User Services  
Oak Ridge National Laboratory  
P.O. Box 2008 MS-6407  
Oak Ridge, TN 37831-6407  
Phone: (423) 241-3952  
Fax: (423) 574-4665  
E-mail: ornl daac@ornl.gov or ornl@eos.nasa.gov

### **15.2 Data Center Identification**

Earth Observing System Data and Information System (EOSDIS) Oak Ridge National Laboratory (ORNL) Distributed Active Archive Center (DAAC) for Biogeochemical Dynamics  
<http://www-eosdis.ornl.gov/>.

### **15.3 Procedures for Obtaining Data**

Users may obtain data directly through the ORNL DAAC online search and order system [<http://www-eosdis.ornl.gov/>] and the anonymous FTP site [<ftp://www-eosdis.ornl.gov/data/>] or by contacting User Services by electronic mail, telephone, fax, letter, or personal visit using the contact information in Section 15.1.

### **15.4 Data Center Status/Plans**

The ORNL DAAC is the primary source for BOREAS field measurement, image, GIS, and hardcopy data products. The BOREAS CD-ROM and data referenced or listed in inventories on the CD-ROM are available from the ORNL DAAC.

## **16. Output Products and Availability**

### **16.1 Tape Products**

None.

### **16.2 Film Products**

None.

### **16.3 Other Products**

These data are available on the BOREAS CD-ROM series.

## **17. References**

### **17.1 Platform/Sensor/Instrument/Data Processing Documentation**

None.

### **17.2 Journal Articles and Study Reports**

Newcomer, J., D. Landis, S. Conrad, S. Curd, K. Huemmrich, D. Knapp, A. Morrell, J. Nickeson, A. Papagno, D. Rinker, R. Strub, T. Twine, F. Hall, and P. Sellers, eds. 2000. Collected Data of The Boreal Ecosystem-Atmosphere Study. NASA. CD-ROM.

Sellers, P. and F. Hall. 1994. Boreal Ecosystem-Atmosphere Study: Experiment Plan. Version 1994-3.0, NASA BOREAS Report (EXPLAN 94).

Sellers, P. and F. Hall. 1996. Boreal Ecosystem-Atmosphere Study: Experiment Plan. Version 1996-2.0, NASA BOREAS Report (EXPLAN 96).

Sellers, P., F. Hall, and K.F. Huemmrich. 1996. Boreal Ecosystem-Atmosphere Study: 1994 Operations. NASA BOREAS Report (OPS DOC 94).

Sellers, P., F. Hall, and K.F. Huemmrich. 1997. Boreal Ecosystem-Atmosphere Study: 1996 Operations. NASA BOREAS Report (OPS DOC 96).

Sellers, P., F. Hall, H. Margolis, B. Kelly, D. Baldocchi, G. den Hartog, J. Cihlar, M.G. Ryan, B. Goodison, P. Crill, K.J. Ranson, D. Lettenmaier, and D.E. Wickland. 1995. The boreal ecosystem-atmosphere study (BOREAS): an overview and early results from the 1994 field year. Bulletin of the American Meteorological Society. 76(9):1549-1577.

Sellers, P.J., F.G. Hall, R.D. Kelly, A. Black, D. Baldocchi, J. Berry, M. Ryan, K.J. Ranson, P.M. Crill, D.P. Lettenmaier, H. Margolis, J. Cihlar, J. Newcomer, D. Fitzjarrald, P.G. Jarvis, S.T. Gower, D. Halliwell, D. Williams, B. Goodison, D.E. Wickland, and F.E. Guertin. 1997. BOREAS in 1997: Experiment Overview, Scientific Results and Future Directions. Journal of Geophysical Research 102(D24): 28,731-28,770.

### **17.3 Archive/DBMS Usage Documentation**

None.

## **18. Glossary of Terms**

None.

## **19. List of Acronyms**

AES	- Atmospheric Environment Service
AFM	- Aircraft Flux and Meteorology
AIR	- Atmospheric Instrumentation Research
ASCII	- American Standard Code for Information Interchange
BOREAS	- BOReal Ecosystem-Atmosphere Study
BORIS	- BOREAS Information System
CD-ROM	- Compact Disk-Read-Only Memory
DAAC	- Distributed Active Archive Center
EOS	- Earth Observing System
EOSDIS	- EOS Data and Information System
GIS	- Geographic Information System
GMT	- Greenwich Mean Time
GSFC	- Goddard Space Flight Center
HTML	- HyperText Markup Language
IFC	- Intensive Field Campaign
NAD83	- North American Datum of 1983
NASA	- National Aeronautics and Space Administration
NSA	- Northern Study Area
OA	- Old Aspen
ORNL	- Oak Ridge National Laboratory
PANP	- Prince Albert National Park
SSA	- Southern Study Area
TF	- Tower Flux
URL	- Uniform Resource Locator



## **20. Document Information**

### **20.1 Document Revision Date**

Written: 26-May-1999

Revised: 08-Oct-1999

### **20.2 Document Review Date(s)**

BORIS Review: 18-Aug-1999

Science Review:

### **20.3 Document ID**

### **20.4 Citation**

When using these data, please include the following acknowledgment as well as citations of relevant papers in Section 17.2:

Data were collected and processed by Robert E. Mickle and A. James Arnold of the Atmospheric Environment Service.

If using data from the BOREAS CD-ROM series, also reference the data as:

Mickle, R.E., A.J. Arnold, and G. den-Hartog, "AES Flux Tower Measurements for BOREAS: Exchange of Energy, Water Vapor, and Trace Gases Project." In Collected Data of The Boreal Ecosystem-Atmosphere Study. Eds. J. Newcomer, D. Landis, S. Conrad, S. Curd, K. Huemmrich, D. Knapp, A. Morrell, J. Nickeson, A. Papagno, D. Rinker, R. Strub, T. Twine, F. Hall, and P. Sellers. CD-ROM. NASA, 2000.

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